5.16.18 AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD (Kansas Test Method KT-18)

a. SCOPE

a.1. This method of test covers the procedure for determining the air content of freshly mixed concrete by the pressure method. KT-18 reflects testing procedures found in AASHTO T 152.

a.2. This method is intended for use with concrete and mortar made with relatively dense aggregates for which the aggregate correction factor can be satisfactorily determined by the technique described in **d**. It is not applicable to concrete made with lightweight aggregates, air-cooled blast furnace slag or aggregates of high porosity. If the Aggregate Correction Factor equals or exceeds 0.8 percent, then KT-19 should also be performed at least once to verify the accuracy of the pressure meter. This test method is not applicable to nonplastic concrete such as commonly used in the manufacture of pipe and concrete masonry units. It is not applicable, without a special calibration, in the following conditions: 1) Concrete slump is two inches or less. 2) A midrange or a super plasticizer is used. 3) An air entraining agent other than a vinsol resin is used.

b. REFERENCED DOCUMENTS

b.1. KT-17; Sampling Fresh Concrete

b.2. KT-19; Air Content of Freshly Mixed Concrete by the Volumetric Method

b.2. KT-20; Mass per Cubic Meter (Foot), Yield Cement Factor and Air Content (Gravimetric) of Fresh Concrete

b.3. AASHTO T 152; Air Content of Freshly Mixed Concrete by the Pressure Method[1]

c. APPARATUS

c.1. An air meter consisting of a measuring bowl and cover assembly conforming to the requirements of **c.2.** and **c.3.** The operational principle of this meter consists of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample, the dial on the pressure being calibrated in terms of percent air for the observed pressure at which equalization takes place. Working pressures of 51 to 207 kPa (7.5 to 30.0 psi) have been used satisfactorily.

c.2. Measuring Bowl: The measuring bowl shall be essentially cylindrical in shape, made of steel, hard metal, or other hard material not readily attacked by the cement paste, having a minimum diameter equal to 0.75 to 1.25 times the height, and a capacity of at least 0.006 m^3 (0.20 ft^3). It shall be flanged or otherwise constructed to provide for a pressure tight fit between bowl and cover assembly. The interior surfaces of the bowl and surfaces of rims, flanges and other component fitted parts shall be machined smooth. The measuring bowl and cover assembly shall be sufficiently rigid to limit the expansion factor, D, of the

[1] While AASHTO and ASTM allows use of two types of pressure meters, Type A and Type B, KDOT allows only Type B meter.

apparatus assembly (see **g.4.a.**) to not more than 0.1 percent of air content on the indicator scale when under normal operating pressure.

c.3. Cover Assembly:

c.3.a. The cover assembly shall be made of steel, hard metal, or other hard material not readily attacked by the cement paste. It shall be flanged or otherwise constructed to provide for a pressure-tight fit between bowl and cover assembly and shall have machined smooth interior surfaces contoured to provide an air space above the level of the top of the measuring bowl. The cover shall be sufficiently rigid to limit the expansion factor of the apparatus assembly as prescribed in **c.2.**

c.3.b. The cover shall be fitted with a means of direct reading of the air content. The dial of the pressure gauge shall be calibrated to indicate the percent of air. Gradations shall be provided for a range in air content of at least 8% easily readable to 0.1% as determined by the proper air calibration test.

c.3.c. The cover assembly shall be fitted with air valves, air bleeder valves, and petcocks for bleeding off or through which water may be introduced as necessary for the particular meter design. Suitable means for clamping the cover to the bowl shall be provided to make a pressure-tight seal without entrapping air at the joint between the flanges of the cover and bowl. A suitable hand pump shall be provided with the cover either as an attachment or as an accessory.

c.4. Calibration Vessel: A measure having an internal volume equal to a percent of the volume of the measuring bowl corresponding to the approximate percent of air in the concrete to be tested; or, if smaller, it shall be possible to check calibration of the meter indicator at the approximate percent of air in the concrete to be tested by repeated filling of the measure. When the design of the meter requires placing the calibration vessel within the measuring bowl to check calibration, the measure shall be cylindrical in shape and of an inside depth 13 mm (0.5 in) less than that of the bowl. A satisfactory measure of this type may be machined from No. 16 gage brass tubing, of a diameter to provide the volume desired, to which a brass disk 13 mm (0.5 in) in thickness is soldered to form an end. When the design of the meter requires withdrawing of water from the water-filled bowl and cover assembly to check calibration, the measure may be an integral part of the cover assembly or may be a separate cylindrical measure similar to the above described cylinder.

c.5. Tamping rod shall be a round straight steel rod, 16 mm (0.625 in) in diameter and not less than approximately 400 mm (16 in) in length, having the tamping end rounded to hemispherical tip the diameter of which is 16 mm (0.625 in).

c.6. Mallet: A mallet (with a rubber or rawhide head) weighing approximately 0.57 $\pm$ 0.23 kg (1.25 $\pm$ 0.50 lb) for use with measures of 0.014 m^3 (0.5 ft^3) or smaller, and a mallet weighing approximately 1.02 $\pm$ 0.23 kg (2.25 $\pm$ 0.50 lb) for use with measures larger than 0.014 m^3 (0.5 ft^3).

c.7. Strike-Off Bar: A flat straight bar of steel or other suitable metal at least 3 mm (0.125 in) thick and 20 mm (0.75 in) wide by 300 mm (12 in) long.

c.8. Strike-off Plate: A flat rectangular metal plate at least 6 mm (0.25 in)thick or a glass or acrylic plate at least 12 mm (0.5 in) thick with a length and width at least 50 mm (2 in) greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of 1.5 mm (0.0625 in).

c.9. Funnel, with the spout fitting into spray tube.

c.10. Vibrators, Internal vibrators may have rigid or flexible shafts, preferably powered by electric motors. The frequency of vibration shall be 7,000 per minute or greater while in use. The outside diameter or side dimension of the vibrating elements shall be at least 19 mm (0.75 in) and not greater than 38 mm (1.50 in). The combined length of the shaft and vibrating element shall exceed the maximum depth of the section being vibrated by at least 76 mm (3 in). External vibrators may be of two types: table or plank. The frequency for external vibrators shall be not less than 3,600 per minute, and preferably higher. For both table and plank vibrators, provision shall be made for clamping the mold securely to the apparatus. A vibrating-reed tachometer should be used to check the frequency of vibration.

c.11. Trowel.

d. DETERMINATION OF AGGREGATE CORRECTION FACTOR

d.1. Procedure: Determine the aggregate correction factor on a combined sample of fine and coarse aggregate as directed in **d.2.** and **d.4.** It is determined independently by applying the calibrated pressure to a sample of inundated fine and coarse aggregate in approximately the same moisture condition, amount, and proportions occurring in the concrete sample under test.

d.2. Aggregate Sample Size: Calculate the mass of fine and coarse aggregate present in the sample of fresh concrete whose air content is to be determined, as follows**:**

(1) $$F_s = \frac{(S)\,(F_b)}{B}$$

(2) $$C_s = \frac{(S)\,(C_b)}{B}$$

where:

F_s = Mass of fine aggregate in concrete sample under test, kg (lb),

S = volume of concrete sample (same as volume of measuring bowl) m³ (ft³),

B = Volume of concrete produced per batch[a], m³ (ft³),

F_b = total mass of fine aggregate in the moisture condition used in batch kg (lb),

C_s = mass of coarse aggregate in concrete sample under test, kg (lb),and

C_b = total mass of coarse aggregate in the moisture condition used in batch, kg (lb).

NOTE a: The volume of concrete produced per batch can be determined in accordance with applicable provisions of KT-20.

d.3. Placement of Aggregates in Measuring Bowl: Mix representative samples of fine aggregate F_s, and coarse aggregate C_s, and place in measuring bowl filled one-third full with water. Place the mixed aggregate, a small amount at a time, into the measuring bowl; if necessary, add additional water so as to inundate all of the aggregate. Add each scoopful in a manner that will entrap as little air as possible and remove accumulations of foam promptly. Tap the sides of the bowl and lightly rod the upper 25 mm (1 in) of the aggregate about ten times. Stir after each addition of aggregate to eliminate entrapped air.

d.4. Aggregate Correction Factor Determination[b]:

d.4.a. Initial Procedure: When all the aggregate has been placed in the measuring bowl, remove excess foam and keep the aggregate inundated for a period of time approximately equal to the time between introduction of the water into the mixer and the time of performing the test for air content before proceeding with the determination as directed in **d.4.b.**

NOTE b: The aggregate correction factor will vary with different aggregates. It can be determined only by test, since apparently it is not directly related to absorption of the particles. The test can be easily made and must not be ignored. Ordinarily the factor will remain reasonably constant for given aggregates, but an occasional check test is recommended.

d.4.b. Remove a volume of water from the assembled and filled apparatus approximately equivalent to the volume of air that would be contained in a typical concrete sample of a size equal to the volume of the bowl. Remove the water in the manner described in **g.4.c.** Complete the test as described in **e.8.** The aggregate correction factor, G, is equal to the reading on the air-content scale minus the volume of water removed from the bowl expressed as a percent of the volume of the bowl.

e. TEST PROCEDURE

e.1. Obtain a sample of fresh concrete in accordance with KT-17.

e.1.a. Dampen the inside of the bowl with a damp cloth prior to running the test.

e.2. Methods of Consolidation: Concrete at different slump levels require different methods of consolidation to prepare satisfactory test specimens. The methods listed below should be used as a guide in determining the type of consolidation to use:

Slump of Concrete	Type of Consolidation
More than 75 mm (3 in)	Rodding
25 to 75 mm (1 to 3 in)	Rodding or Vibration
less than 25 mm (1 in)	Vibration

e.3. Rodding Procedure.

e.3.a. Place the concrete in the base in three equal layers.

e.3.b. Rod each layer 25 times. When rodding the first layer, avoid striking the bottom of the container and when rodding successive layers, use only enough force to penetrate the surface of the underlying layer about 25 mm (1 in). Add final layer of concrete in a manner to avoid excessive overfilling.

e.3.c. After each layer is rodded, tap the sides of the measure smartly 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air that may have been trapped.

e.4. Vibration Procedure.

e.4.a. Fill the base approximately 1/2 full of concrete. Place all the concrete required for the layer in the mold before starting vibration.

e.4.b. Consolidate the layer by three insertions of the vibrator evenly distributed over the surface. Vibrate until the concrete is properly consolidated. The duration of vibration will depend on the effectiveness of the vibrator and the consistency of the concrete, but usually sufficient vibration has been applied when the surface of the concrete becomes relatively smooth in appearance.

e.4.c. Fill the base to an elevation somewhat above the top rim and vibrate this second layer. A smaller quantity of concrete may be added to correct a deficiency. If the base contains a great excess of concrete at completion of consolidation, remove a representative portion of the excess concrete with a trowel or scoop immediately and before the base is struck off.

e.4.d. Special Precautions.

e.4.d.1. Do not allow the vibrator to rest on the bottom or touch the sides of the base when vibrating the bottom layer.

e.4.d.2. When vibrating the top layer, penetrate that layer and approximately the top 25 mm (1 in) of the bottom layer.

e.4.d.3. Withdraw the vibrator in such a manner that no air pockets are left in the specimen.

e.5. Strike off the excess concrete, level full, with the straight edge or the glass plate and thoroughly clean the flanges of the bowl and the cover to insure an air tight fit.

e.6. Clamp on the cover with the petcocks open and close air valve.

e.7. Using a rubber syringe, inject water through one petcock until water is expelled through the opposite petcock. Jar meter gently until all air is expelled from this same petcock. Leave petcocks open.

e.8. Close the air bleeder valve on the air chamber and pump air into the air chamber until the gage hand is on the initial pressure line. Allow a few seconds for the compressed air to cool to normal temperature. Stabilize the gage hand at the initial pressure line by pumping or bleeding-off air as necessary, tapping the gage lightly by hand. Close both petcocks on the holes through the cover. Open the air valve between the air chamber and the measuring bowl. Tap the sides of the measuring bowl smartly with the mallet to relieve local restraints. Lightly tap the pressure gage by hand to stabilize the gage hand and read the percentage of air on the dial of the pressure gage. Failure to close the main air valve before releasing the pressure from either the container or the air chamber will result in water being drawn into the air chamber, thus introducing error in subsequent measurements. In the event water enters the air chamber it must be bled from the air chamber through the bleeder valve followed by several strokes of the pump to blow out the last traces of water. Release the pressure by opening both petcocks before removing the cover.

e.9. Clean the base, cover and petcock openings.

f. CALCULATION

f.1. Air Content of Sample Tested: Calculate the air content of the concrete in the measuring bowl as follows:

$$A_s = A_1 - G$$

WHERE:

A_s = air content of sample tested, percent,

A_1 = apparent air content of the sample tested, percent, and

G = aggregate correction factor, percent.

g. CALIBRATION OF METER GAUGE

g.1. Calibration of the Calibration Vessel: Determine accurately the mass of water, w, required to fill the calibration vessel, using a scale accurate to 0.1% of the mass of the vessel filled with water.

g.2. Calibration of the Measuring Bowl: Determine the mass of water, W, required to fill the measuring bowl, using a scale accurate to 0.1% of the mass of the bowl filled with water. Slide a glass plate carefully over the flange of the bowl in a manner to ensure that the bowl is completely filled with water. A thin film of cup grease smeared on the flange of the bowl will make a watertight joint between the glass plate and the top of the bowl.

g.3. Effective Volume of the Calibration Vessel, R: The constant R represents the effective volume of the calibration vessel expressed as a percentage of the volume of the measuring bowl. Calculate R as follows:

$$\mathbf{R = w/W}$$

where:

w = weight of water required to fill the calibration vessel, and
W = weight of water required to fill the measuring bowl.

g.4. Determination of, or Check of, Allowance for Expansion Factor, D:

g.4.a. The allowance factor for the expansion factor, D, is included in the difference between the initial pressure indicated on the pressure gage and the zero % mark on the air-content scale on the pressure gage. This allowance shall be checked by filling the apparatus with water (making certain all entrapped air has been removed), pumping air into the air chamber until the gage hand is stabilized at the indicated initial pressure line, and then releasing the air to the measuring bowl[c]. If the initial pressure line is correctly positioned, the gage should read zero %. The initial pressure line shall be adjusted if two or more determinations show the same variation from zero % and the test repeated to check the adjusted initial pressure line.

NOTE c: This procedure may be accomplished in connection with the calibration test described in **g.4.c.**

g.4.b. Calibration Reading, K: The calibration reading, K, is the final meter reading to be obtained when the meter is operated at the correct calibration pressure. The calibration reading, K, equals the effective volume of the calibration vessel as follows:

$$\mathbf{K = R}$$

g.4.c. Calibration Test to Check the Air Content Graduations on the Pressure gage: Fill the measuring bowl with water as described in **g.2.** Screw the short piece of tubing or pipe furnished with the apparatus into the threaded petcock hole on the underside of the cover assembly. Assemble the apparatus. Close the air valve between the air chamber and the measuring bowl and open the two petcocks on holes through the cover assembly. Add water through the petcock on the cover assembly having the extension below until all air is expelled from the second petcock. Pump air into the air chamber until the pressure reaches the indicated pressure line. Allow a few seconds for the compressed air to cool to normal temperature. Stabilize the gage hand at the initial pressure line by pumping or bleeding off air as necessary, tapping the gage lightly. Close the petcock that does not have the tube or extension on the under side of the cover. Remove water from the assembly to the calibrating vessel controlling the flow by opening the petcock provided with the tube or pipe extension and cracking the air valve between the air chamber and the measuring bowl, or by opening the air valve and using the petcock to control flow. Perform the calibration at an air content which is within the normal range of use. If the calibration vessel has a capacity within the normal range of use, remove exactly that amount of water. With some meters the calibrating vessel is quite small and it will be necessary to remove several times that volume to obtain an air content within the normal range of use. In this instance, carefully collect the water in an auxiliary container and determine the amount removed by weighing to the nearest 0.1%. Calculate the correct air content, R, by using the equation in **g.3.** Release the air from the apparatus at the petcock not used for filling the calibration vessel and if the apparatus employs an auxiliary tube for filling the calibration container, open the petcock to which the tube is connected to drain the tube back into the measuring bowl[d]. At this point of procedure the measuring bowl contains the percentage of air determined by the calibration test of the calibrating vessel. Pump air into the air chamber until the pressure reaches the initial pressure line marked on the pressure gage, close both petcocks in the cover assembly, and then open the valve between the air chamber and the measuring bowl. The indicated air content on the pressure gage dial should correspond to the percentage of air determined to be in the measuring bowl. If two or more determinations show the same variations from the correct air content, the dial hand shall be reset to the correct air content and the test repeated until the gage reading corresponds to the calibrated air content within 0.1%. If the dial hand was reset to obtain the correct air content, recheck the initial pressure mark as in **g.4.a.** If a new initial pressure reading is required, repeat the calibration to check the accuracy of the gradation on the pressure gage described earlier in this section. If difficulty is encountered in obtaining consistent readings, check for leaks, for the presence of water in the air chamber, or the presence of air bubbles clinging to the inside surfaces of the meter from the use of cool aerated water. In this latter instance use deaerated water which can be obtained by cooling hot water to room temperature.

NOTE d: If the calibrating vessel is an integral part of the cover assembly, the petcock used in filling the vessel shall be closed immediately after filling the calibration vessel and not opened until the test is complete.

Calculation of Yield Cement Factor.

The Yield Cement Factor of a concrete sample can be calculated using the Design Cement Factor, the Design Percent Air and The Actual or Measured Percent Air.

Actual YCF (with measured air content GREATER than design).

$$= \frac{\text{Design YCF}}{1+ \dfrac{(\text{measured \% air - design \% air})}{100}}$$

Actual YCF (with measured air content LESS than design).

$$= \frac{\text{Design YCF}}{1- \dfrac{(\text{design \% air - measured \% air})}{100}}$$

When the measured percent air is higher than the design percent air, the volume of aggregate, water and cement will be less than the designed volumes within 0.95 m^3 (1 yd^3). With the reduction of volume of cement per m^3 (yd^3), the weight of cement per m^3 (yd^3) will be less and therefore the YCF (kg of cement/m^3 [lb of cement/yd^3]) will be less than the Design YCF. When the measured percent air is lower than the design percent air, the converse is true and the Actual YCF is higher than the Design YCF.

h. SPECIAL CALIBRATION

h.1. Taking six samples of the concrete covering the specified range of air content. Run air tests with both the pressure and the rollameter. Calibration is based on the rollermeter comparison.